# PATENT SPECIFICATION

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## (54) AN AID FOR USE IN TEACHING CHEMISTRY

(71) I, PETER *OH* CHOW HUN, a Malaysian citizen, of 52 Jalan Kemajuan, Petaling Jaya, Malaysia, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to an aid for use in teaching chemistry and suitable for illustrating simple chemical compounds.

The present invention provides an aid for use in teaching chemistry comprising a set of individual blocks each representing an ion, some of the blocks being marked with chemical symbols representing cations and some of the blocks being marked with chemical symbols representing anions, the valency of each cation or anion being represented respectively by a corresponding number of projections only or recesses only on each of a plurality of surfaces of the respective block, each projection or recess being adapted to co-operate with a complementary recess or projection respectively on a surface of a block of opposite electrical charge.

The teaching aid according to the invention preferably consists of a set of 28 individual blocks of 10 different types (as hereinafter defined), five of the said types being cations and five of the said types being anions, there being three blocks of each type except for one of the cations and for one of the anions which have two blocks each. By a block of a certain type is meant that the block is marked on a plurality of its surfaces with chemical symbols representing either one or more cations or one or more anions.

Preferably the blocks are rectangular in cross-section, and more preferably they have a number of co-operating projections or recesses corresponding to their valency on each of four surfaces.

For example, an anion with a valency of 3 will have three recesses on each of four surfaces and a cation with a valency of 3 or 3 cations each with a valency of 1 could be plugged into the recesses in the anion. For example, three blocks representing a hydrogen ion would each have one projection on each of four surfaces and these could be plugged into the recesses on one surface of an anion representing the phosphate anion, $PO_4^{---}$. The complete unit thus represents phosphoric acid $H_3PO_4$, and the chemical structure of the compound can be seen in a simple way. As another example sodium carbonate comprises a rectangular block having two recesses on each surface to represent the $CO_3^{--}$ anion and two single blocks with one projection on each surface to represent the sodium cation. Sodium carbonate, $Na_2CO_3$, therefore comprises the carbonate anion with the two sodium cations plugged into one surface.

The invention will now be described in more detail, by way of example only, with reference to the diagrammatic drawings accompanying the Provisional specification, in which:—

Figure 1 shows a cation and an anion; and

Figure 2 shows a chemical compound formed with blocks.

The blocks are designed to help students in secondary schools understand the basic principles of inorganic chemistry with regard to valency, atomic number, atomic weight and chemical combination.

There are 28 plastic blocks in the set of teaching apparatus, each representing an "ion". Students are asked to identify the various blocks before applying them, four of the six surfaces of each block being used.

A block with one projection on each of the four surfaces is a "cation", or positively charged ion. A single (+) sign against the symbol represents a positive electrovalency of 1. A block with two projections on each of the four surfaces has a positive electro-valency of 2 and is provided with the (2+) or double (+) sign. A block with three projections on each of the four surfaces has a positive electrovalency of 3, hence the (3+) or triple (+) sign.

On the other hand, a block with one recess on each of the four surfaces is an "anion", or negatively charged ion. The single (−) sign against the symbol represents a negative electro-valency of 1, which indicates the gain of an electron in its outermost shell. Similarly, a block with two recesses on each of the four surfaces has a negative electro-valency of 2

because of two acquired electrons in its outermost shell, hence the (2−) or double (−) sign. A block with three recesses on each of the four surfaces has a negative electro-valency of 3, hence the (3−) or triple (−) sign.

The symbol on each surface represents an element (or group or radical, such as $NH_4^+$, $OH^-$, $SO_4^{2-}$, etc.) and the set of numbers below it is its electron structure. Some surfaces are left blank for the students to insert as necessary whatever appropriate symbols not included in this set.

The number on the top right-hand corner is the atomic number of the element. It is equal to the number of protons in the nucleus of each atom and which is equal to the number of electrons outside the nucleus.

The number on the top left-hand corner is the atomic weight of the element. It is equal to the sum of the protons and neutrons in the nucleus of each atom. For the lighter atoms, the number of protons and neutrons are about equal such that the atomic weight is about twice its atomic number, except for hydrogen which has only a single proton and no neutron in its nucleus.

There are altogether preferably 28 blocks and they are numbered from 1 to 10, preferably on their two surfaces: Nos. 1 to 5 preferably being cations and Nos. 6 to 10, preferably being anions. Except for Nos. 5 and 10, which have 2 blocks each, all other numbers have 3 blocks each. These numbers will help students to identify them in the following lessons.

In Figure 1 the ions of sodium and chlorine are shown and these can be plugged together to form sodium chloride. In Figure 2, sodium carbonate is shown with the two sodium cation blocks plugged into a single carbonate anion block. This of course has two recesses on each of four of its surfaces owing to its valency of 2.

The teaching aid is intended to be manufactured in plastics material in the following dimensions:— 2 cm×2 cm×2 cm for univalent blocks, 4 cm×2 cm×2 cm for divalent blocks, and 6 cm×2 cm×2 cm for trivalent blocks with the intention that it will be handy and not occupy too much space in the student's schoolbag.

As a teaching aid, it may be necessary to manufacture comparatively larger sets so that they are more visible to the students sitting at the back of the classroom. However, the idea is to make it handy and cheap so that every secondary school student studying chemistry can afford to own a set to help him learn the subject.

The applications of the teaching aid will now be described in detail.

Atoms combine together in such a manner that their outermost electron structures achieve that of a rare gas (or inert gas). A rare gas always possesses 8 electrons in its outermost shell (i.e. an octet), except for helium which has a duplet (i.e. 2 electrons in its outermost shell). This structure is very stable and difficult to disturb. There is a general tendency for all other elements to try to attain this rare gas structure of a stable outer-octet (or duplet) of electrons by chemical combination: that is by electro-valency (or electron-transfer) and by covalency (or electron-sharing).

In electro-valency, a metallic element or group normally transfers from its outermost electron shell a number of electrons equal to its valency over to the outermost electron shell of a non-metallic element or group in a chemical combination. In this way, an electron octet is left behind in the metal and created in the non-metal. Both these elements or groups now have the stable outermost electron structure of a rare gas; but the metallic particles become positively charged from the excess proton or protons left in the nucleus while the non-metallic particles become negatively charged from the gained electron or electrons.

We know that the atomic number of an element is equal to the number of protons in the nucleus and which is also equal to the number of electrons outside the nucleus. The electron structure as indicated below the symbol of each element in this set of apparatus will help us determine its valency and electrical charge. This is by referring to the number of electrons in its outermost shell. Let us look at the atomic number and electron structure of a few elements:—

Oxygen has the atomic number of 8; therefore, it has 8 electrons orbiting outside the nucleus with 2 electrons in the first shell and the remaining 6 electrons in its outer shell. To attain the stable electron structure of a rare gas, 2 extra electrons are to be acquired from those in the element it will combine with. Thus, it is said to have a valency of 2, and these excess electrons will create a negative electrical charge in it.

Sodium has the atomic number of 11; therefore, it has 11 electrons, 2 electrons in the first shell, 8 electrons in the second shell, and 1 electron in the outermost shell. To attain the stable electron structure of a rare gas, its free electron in the outermost shell has to be released to the element it will combine with. Thus, it is said to have a valency of 1, and the excess proton or loss of an electron will create a positive electrical charge in it.

We can now learn how atoms combine to form compounds by using these blocks.

To obtain correct chemical formulae, it is necessary to join up the cation blocks with anion blocks face to face until the recess or recesses on one surface are plugged up by the projection or projections of another surface.

Each block may be marked with up to four symbols representing various elements on its respective surfaces, for example one cation may be marked with symbols representing

sodium, potassium, cuprous copper and silver ions.

Thus we can (for example) take a piece of such a block representing a cation and join up with a piece of a block representing an anion marked on its surfaces with symbols representing fluorine, chlorine, bromine and iodine ions to give us as many as 16 chemical formulae, namely:—

$$Na^+ + F^- \rightarrow NaF;$$

$$Na^+ + Cl^- \rightarrow NaCl;$$

$$Na^+ + Br^- \rightarrow NaBr;$$

$$Na^+ + I^- \rightarrow NaI;$$

$$K^+ + F^- \rightarrow KF;$$

$$K^+ + Cl^- \rightarrow KCl;$$

$$K^+ + Br^- \rightarrow KBr;$$

$$K^+ + I^- \rightarrow KI;$$

$$Cu^+ + F^- \rightarrow CuF;$$

$$Cu^+ + Cl^- \rightarrow CuCl;$$

$$Cu^+ + Br^- \rightarrow CuBr;$$

$$Cu^+ + I^- \rightarrow CuI;$$

$$Ag^+ + F^- \rightarrow AgF;$$

$$Ag^+ + Cl^- \rightarrow AgCl;$$

$$Ag^+ + Br^- \rightarrow AgBr;$$

$$Ag^+ + I^- \rightarrow AgI.$$

We can also for example take two pieces of a block representing a cation and join up with a piece of a block representing a divalent anion to give us 6 chemical formulae, the cation being marked with symbols representing hydrogen and ammonium ions only and the anion being marked with symbols representing sulphite, sulphate and carbonate ions only, namely:—

$$2H^+ + SO_3^{2-} \rightarrow H_2SO_3;$$

$$2H^+ + SO_4^{2-} \rightarrow H_2SO_4;$$

$$2H^+ + CO_3^{2-} \rightarrow H_2CO_3;$$

$$2NH_4^+ + SO_3^{2-} \rightarrow (NH_4)_2SO_3;$$

$$2NH_4^+ + SO_4^{2-} \rightarrow (NH_4)_2SO_4;$$

$$2NH_4^+ + CO_3^{2-} \rightarrow (NH_4)_2CO_3.$$

There are almost 200 chemical formulae we can form by combining various blocks of different electrical charges. If any element or group is not included in this set of apparatus, use can be made of some of the blank surfaces on these blocks with the appropriate electrical charges.

Let us examine how some of these compounds are formed:—

The chemical formula for sodium chloride is NaCl and it is formed by combining one sodium atom with one chlorine atom. The single valency electron in the outermost shell of the sodium atom is transferred to the outermost shell of the chlorine atom to form two ions, $Na^+$ and $Cl^-$, both having the stable electron structure of a rare gas but different electrical charges.

Calcium oxide, CaO, is formed by combining one calcium atom with one oxygen atom. The two valency electrons in the outermost shell of the calcium atom are transferred to the outermost shell of the oxygen atom to form ions $Ca^{++}$ and $O^{--}$, both having the stable electron structure of a rare gas but different electrical charges.

It should be noted that when compounds formed by electro-valency are melted or dissolved in water, the parts of the compounds as held together will separate to form free ions. They will conduct electricity and are, therefore, electrolytes.

e.g. $CuSO_4 \rightarrow Cu^{++} + SO_4^{--}$ or

$$NaCl \rightarrow Na^+ + Cl^-$$

The percentage weight of elements in any compounds can also be found as follows:—

When sodium combines with chlorine to form sodium chloride, we can determine the quantities or the percentage by weight of both these elements in the compound.

The atomic weight of sodium is 23 and that of chlorine is 35.5, hence it requires 23 grams of sodium to combine with 35.5 grams of chlorine to form 58.5 grams of sodium chloride.

On the other hand, if we dissolve 500 grams of common salt, sodium chloride, in water and subject it to electrolysis, the quantities of $Na^+$ and $Cl^-$ ions liberated are:

$$500 \times \frac{23}{58.5} \text{gm.} = 197 \text{ gm.},$$

and

$$500 \times \frac{35.5}{58.5} \text{gm.} = 303 \text{ gm.},$$

or

$$(500 \text{ gm} - 197 \text{ gm} = 303 \text{ gm.})$$

respectively.

We know that sulphuric acid $H_2SO_4$ is made from sulphur, hence we can calculate the amount of sulphur required to produce a certain quantity of sulphuric acid. Since the atomic weight of sulphur=32 and the molecular weight of

$$H_2SO_4=(1\times2)+(32+16\times4)=98;$$

it therefore requires 32 grams of sulphur to produce 98 grams of sulphuric acid (of 100% concentration).

The described teaching aid has the advantages that:—

1. I can generate greater interest and appreciation in chemistry amongst secondary school students,

2. It can help the students learn this abstract subject in a very practical way, and

3. It is very simple to apply and provides a wide range of formulae that can be constructed. It can be used in the school under the teacher's guidance or at home by the student himself by following its instruction.

WHAT I CLAIM IS:—

1. An aid for use in teaching chemistry comprising a set of individual blocks each representing an ion, some of the blocks being marked with chemical symbols representing cations and some of the blocks being marked with chemical symbols representing anions, the valency of each cation or anion being represented respectively by a corresponding number of projections only or recesses only on each of a plurality of surfaces of the respective block, each projection or recess being adapted to co-operate with a complementary recess or projection respectively on a surface of a block of opposite electrical charge.

2. A teaching aid as claimed in Claim 1 wherein the blocks are rectangular in cross-section.

3. A teaching aid as claimed in Claim 2 wherein the blocks have a number of co-operating projections or recesses corresponding to their valency on each of four surfaces.

4. A teaching aid as claimed in any of Claims 1 to 3 wherein at least some of the surfaces of the blocks are marked with information indicating the atomic number and/or atomic weight and/or electron structure of the ions which they represent.

5. A teaching aid as claimed in any of Claims 1 to 4 consisting of a set of 28 said individual blocks of 10 different types (as hereinbefore defined), five of the said types being cations and five of the said types being anions, there being three blocks of each type except for one of the cations and for one of the anions which have two blocks each.

6. An aid for use in teaching chemistry substantially as herein described with reference to, and as shown in, the drawings accompanying the Provisional Specification.

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Inorganic chemistry teaching aid - has blocks with projections, representing cations and blocks with recesses, representing anions
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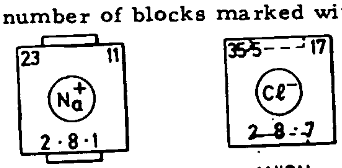
The aid for use in the teaching of chemistry consists of a number of blocks marked with chemical symbols and formed to permit the blocks to be coupled to each other to form chemical compounds. The blocks are e.g. of rectangular shape, with some blocks representing cations and others representing anions.



CATION ANION

The blocks representing cations are provided with projections on its side walls while the blocks representing anions are formed with recesses to accept projections etc.

Valency is indicated by the number of projections or recesses with the atomic number and distribution of electrons in the different shells indicated on the block. There are e.g. 28 blocks in a set with the blocks made from a plastics material. 9.1.75 as (5pp56).

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PROVISIONAL SPECIFICATION
*This drawing is a reproduction of the Original on a reduced scale*

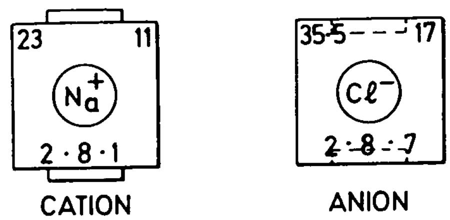


FIG.1.

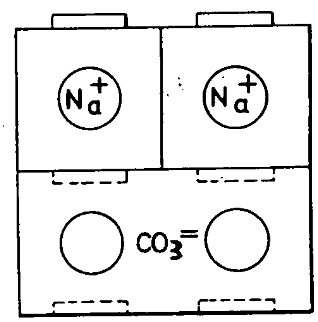


FIG.2.

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